Fishery Data Series No. 98-15

Mortality of Sheefish Captured and Released on Sport Fishing Gear in the Kobuk River, 1997

by

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and

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July 1998

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

Day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
Minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
And	&
At	@
Compass directions:	
East	E
North	N
South	S
West	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

FISHERY DATA SERIES NO. 98-15

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July 1998

Development and publication of this manuscript were partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-13, Job No. R-3-5(c).

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This document should be cited as:
Stuby, L. and T. Taube 1998. Mortality of Sheefish Captured and Released on Sport Fishing Gear in the Kobuk River, 1997. Alaska Department of Fish and Game, Fishery Data Series No. 98-15, Anchorage.

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ABSTRACT

A hooking mortality study on sheefish (*Stenodus leucichthys*) was conducted on the Kobuk River near the confluence of the Pah River. Fish were captured by means of a single-hooked lure (6/0), treble hook lure and beach seine. The primary study objective was to estimate the proportion of sheefish that died due to hook and line sampling. Also, the effects of lure type, hooking location, bleeding severity, landing time and handling time on sheefish mortality and the relationship between hook location and bleeding severity were examined. The mortality rate for the single-hooked lure was 0.016 (SE=0.016) and that for the treble hook lure was 0.032 (SE=0.022). Of the 125 fish sampled by hook and line, only three died as a result of sampling. An Anderson-Darling k-sample test between the fish lengths sampled by the two gear types and the seined controls rejected the null hypothesis of size homogeneity. The median lengths for sheefish captured by single-hooked lures, treble hook lures, and seine were 871 mm, 825 mm, and 893 mm respectively. Contingency table analysis of hook location and severity of bleeding with respect to gear type failed to reject the hypothesis for independence. However, contingency tables comparing hook location to severity of bleeding for both gear types showed a direct relationship. Due to the low number of mortalities, no correlation could be made between landing and handling times on fish mortality. There was an approximately 75% mortality for fish that were hooked in the gills and bleeding severely.

Key words: sheefish, *Stenodus leucichthys*, Kobuk River, hooking mortality, length distributions, spawning, hook and line sampling, beach seine, hook location, bleeding severity, landing time, handling time.

INTRODUCTION

Sheefish (*Stenodus leucichthys*) or inconnu in the Kotzebue Sound drainages of the Kobuk and Selawik rivers are the best understood of all Alaskan populations of sheefish because of their importance to the recreational, subsistence and commercial fisheries of these drainages (Alt 1969, 1987) (Figure 1). Because of their large size and relatively easy access, Kobuk River sheefish are highly sought by sport anglers. However, most guided fishermen release the majority of fish caught (Alt 1987). Since the inception of the Alaska Department of Fish and Game (ADF&G) trophy fish program in 1967, 12 of 14 trophy sheefish registered have been taken from the Kobuk River. All official Hall of Fame 1996 world fresh water fish records of North America (tackle and line class) for sport angled sheefish are from fish caught in the Kobuk River (National Fresh Water Fishing Hall of Fame, Hayward, Wisconsin).

Estimated sport harvests of sheefish from the Kobuk River from 1977 to 1996 averaged 786 fish, ranging from 131 in 1989 to 1,886 in 1982 (Mills 1979-1994, Howe et al. 1995-1997). During this time period, sheefish from the Kobuk River have accounted for 34% of the statewide sport harvest of sheefish and 60% of the sport harvest for northwestern Alaska. Since 1977, estimated catches of these fish from the Kobuk River have averaged 1,316 (Mills 1979-1994, Howe et al. 1995-1997). During this time period, the Kobuk River has accounted for 27% of the statewide and 67% of the northwestern Alaska sport catch of sheefish.

Current sport fishing regulations for sheefish in the Kobuk River are 2 per day, 2 in possession, with no size limit for sheefish upstream of the mouth of the Mauneluk River and 10 per day, 10 in possession, with no size limit for the remainder of the Kobuk River. Prior to 1988 the sport fishing regulations for sheefish in the Kobuk River were 10 fish per day, no possession limit, and no size limit. Concerns for the maintenance of this stock and continuance of this unique trophy fishery were the motivation behind these proposals submitted by ADF&G to and adopted by the Alaska Board of Fisheries in 1987.

No documented hooking mortality studies have been directed towards sheefish or other coregonids. Mark-recapture experiments on the Kobuk River during 1994-1997 used hook and

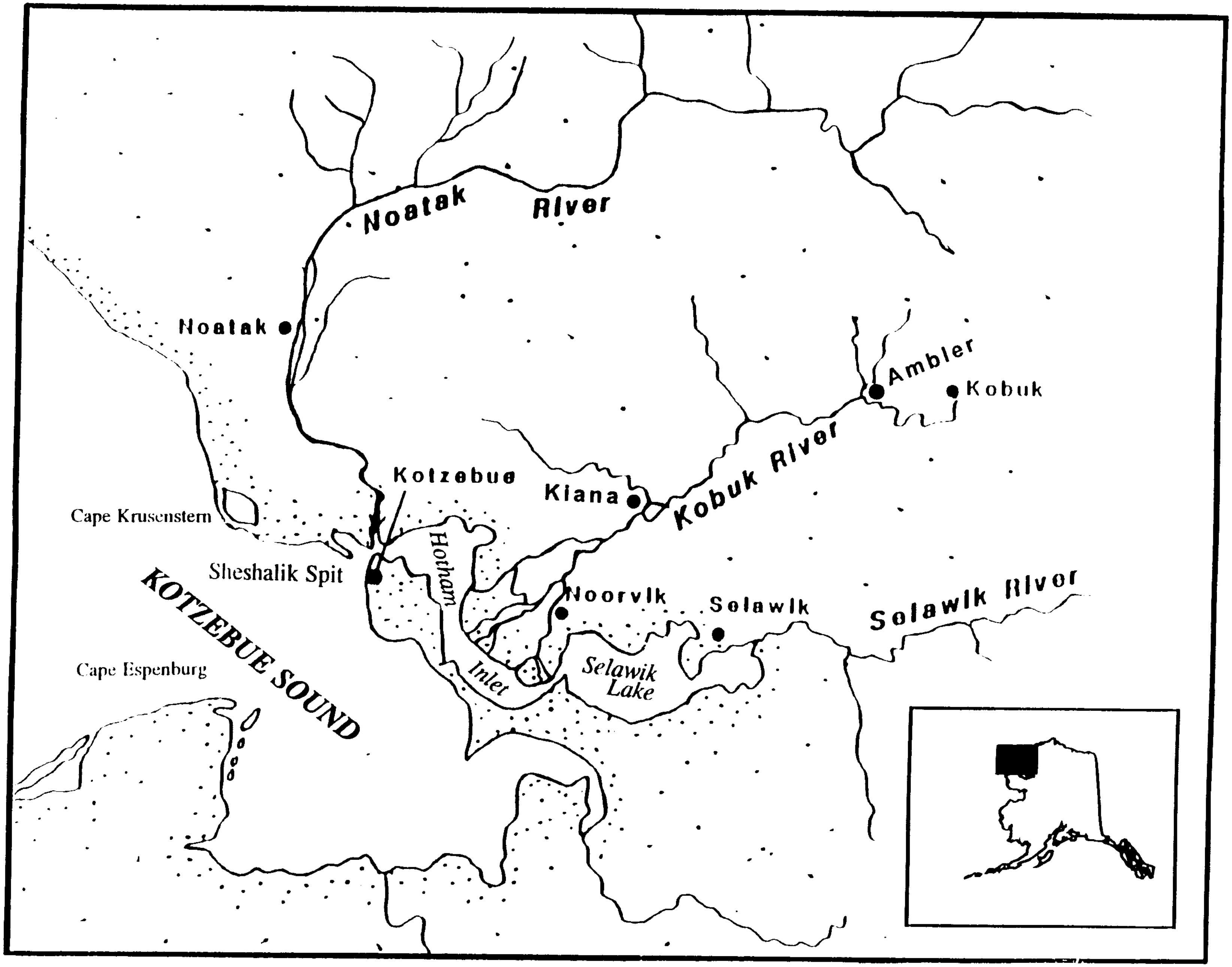


Figure 1.-Map of Kobuk River and surrounding area.

line as a capture method to mark sheefish (Taube 1996, 1997, *in press*). Immediate hook and line sampling mortality during this period was <1% (9 of 4,790). Sheefish captured by hook and line sampling have ranged in size from 535–1,175 mm. Hooking mortalities on other fish species that attain large sizes, have reported low mortality (<10%). Burkholder (1992) reported a mortality of less than 5% in northern pike (265-935 mm) held for 5 days after being caught with sportfishing gear. Bendock and Alexandersdottir (1990) examined mortality in chinook salmon (540-1,160 mm) in the Kenai River sport fishery and found 13% of males and 7% of females died after release. Falk et al. (1974) found 7% mortality in lake trout (320-960 mm) caught on barbed and barbless hooks. These studies determined that bleeding and hook placement were the main cause of death. Schill and Scarpella (1997) conducted a study of previous barbed versus barbless hooking mortality studies on various species of trout. They concluded that the use of barbed or barbless flies or lures plays no role in subsequent mortality of trout caught and released by anglers.

A belief among upper Kobuk River villages that catch and release fishing causes high mortality has raised concern over sport fishing on the upper Kobuk River (Georgette and Loon 1990). During 1994-1995, subsistence harvest of sheefish by the Kobuk River villages averaged 6,323 (Lean et al. 1996), while sport fish catch and harvest averaged 1,528 and 442, respectively, during this same period (Howe et al. 1995, 1996). If mortality of caught and released sheefish is high the annual catch represents additional harvest. In addition, if hooking mortality is high an alternative capture method needs to be used for mark-recapture studies.

OBJECTIVES

The primary project objective was to estimate the proportion of sheefish that die due to hooking such that the estimate is not more than 5 percentage points less than the true proportion 90% of the time for both single and treble hooked gear types. In addition, the effects of lure type, hooking location, bleeding severity, landing time and handling time on sheefish mortality were examined. Lastly, the relationship between hook location and severity of bleeding with respect to each gear type individually and collectively were examined.

METHODS

DATA COLLECTION

The sampling area for the hooking mortality study was located 64 miles upstream of Kobuk Village and approximately 1 km downstream of the Pah River (Figure 2). Hook and line sampling took place on 24 August, and 11, 14 September. High water between 26 August-10 September prevented three consecutive sampling events. When the river level receded to a level at which the holding pen would contain fish, the last two events were then completed. The majority of the 125 fish collected by hook and line were in spawning condition. Approximately 20% of these spawners were ripe.

A six-person crew conducted the field sampling. Sheefish were captured by hook and line using Krocodile spoons (Luhr Jensen, Hood River, Oregon) with either a single or treble hook (6/0) with barbs intact. Fishing gear consisted of a heavy spinning rod and reel and 15-lb. test

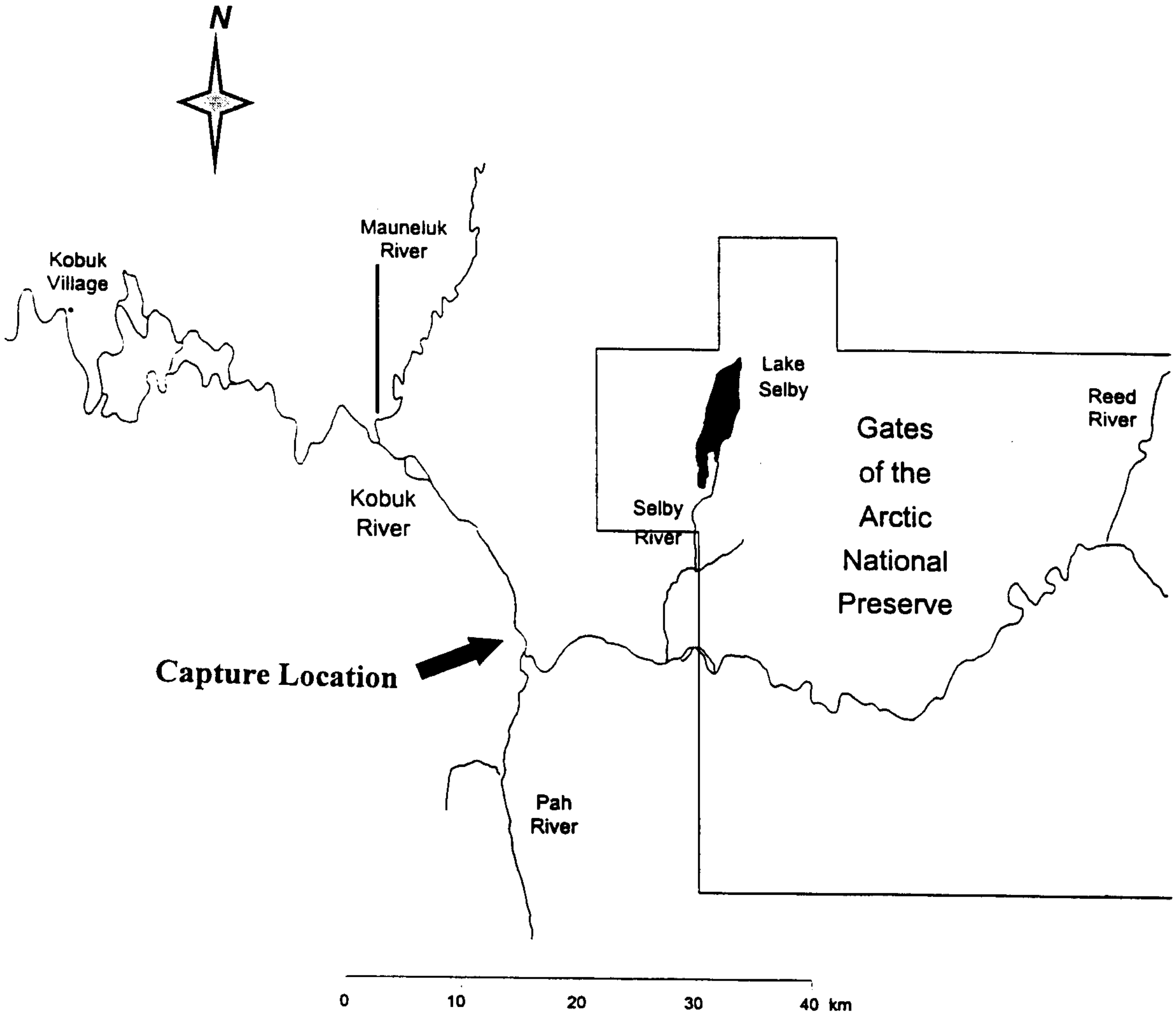


Figure 2.-Area of Kobuk River showing location of hooking mortality study on sheefish, 1997.

monofilament. Each crewmember alternated lure type after the sheefish was caught. Landing time was recorded, which was defined as the point from when a sheefish was hooked to the point when it was landed in the boat. Upon landing, length and sex of the fish were recorded. Fish were measured to the nearest millimeter of fork length. Sex and maturity of each live fish was determined by the presence of sex products. Each fish was marked with an individually numbered Floy FD-67 internal anchor tag inserted at the base of the dorsal fin so that the tag locked between the posterior interneural rays. Fish caught with treble hooks were given green tags, and those captured with single hooks were given blue tags. In case of tag loss, fish were also marked with a secondary finclip. Fish captured with single hooks received a hole punch on the upper caudal fin and those captured with treble hooks received a hole on the lower caudal fin. Fish for which sex could not be determined were recorded as unknown (four fish). Fish were transported to a holding pen as soon as was possible. The holding pen was approximately 50 ft square and was set up on a flat spot in the river, anchored to shore, near the capture location. Handling time was recorded, which was defined as the time between landing and release in the pen. Length, sex, tag number, finclip and date were recorded on Tagging Length Version 1.0 mark-sense forms. In addition, the aforementioned data plus landing time, hook location, and handling time were recorded on a separate form (Appendix A). Three scales from each fish were collected for later age analysis.

A control group of sheefish was seined in order to examine the effects of handling on mortality. Sheefish sampled by beach seine were processed in the manner described above. One boat and a crew of at least four were used during seining. Sheefish were seined in shallow (<2.0 m), high velocity water, usually on the downstream end of a gravel bar. A rope harness was attached to each end of the seine with a 16 m lead. One or two crew members remained on the upstream portion of the gravel bar holding one lead, while the remaining crew pushed the boat into the current. The seine was set as perpendicular (cross-current) to the shore as possible, while the current took the boat downstream. To accomplish this, the onshore crew members would walk the net down the shoreline, until all the net was out and the boat motored the other lead to shore. The ends of the leads were brought together and the seine was pulled to shore. A portion of the seine was left in the water to hold the captured sheefish, until all were processed.

Hook placement was recorded and assigned an identification number as noted in Table 1. The amount of bleeding was rated on a four-point scale adapted from Falk and Gillman (1975). Captured sheefish were held in a pen constructed of fence material to prevent escape. During the study a maximum of 55 fish were held at one time. Four of 138 fish held escaped. The pen was checked on a regular basis during the day for mortalities. Fish from all treatments were placed in the pen. All mortalities were removed from the holding area and tag number and time of day were noted. After 48 h all sheefish remaining in the pen were identified and released.

DATA ANALYSIS

The mortality rate for single and treble hooks was calculated using:

$$\hat{m}_i = \frac{X_i}{n_i} \tag{1}$$

where:

$\hat{m}_i$ = the mortality rate of fish that are caught with gear i;
n_i = the number of fish that are caught with gear i; and,
X_i = the number of fish caught with gear i that die.

The standard error of this rate was estimated by (Zar 1984):

$$SE[\hat{m}_i] = \left[\frac{\hat{m}_i(1-\hat{m}_i)}{(n_i-1)}\right]^{1/2} \qquad (2)$$

Table 1.-Identification numbers and corresponding hook locations and bleeding descriptions. The bleeding severities are based on Falk and Gillman (1975).

Identification Number	Hook Location	Bleeding Severities
0	-	None, no evidence of external bleeding
1	Upper Jaw	Slight, a small amount of bleeding generally localized near the point of hook entry
2	Roof of Mouth	Moderate, a greater amount of external bleeding generally localized around the point of hook entry
3	Esophagus	Severe, copious amounts of bleed, staining the water in the hooding tote and generally surrounding and obscuring the point of hook entry
4	Gills	-
5	Tongue	-
6	Lower Jaw	-
7	Snag	-
8	Eye	-

A minimum sample size of 60 sheefish per gear type was needed for the analysis in order to test the null hypothesis that mortality for a treatment would not exceed 10%. Based on the sample size and power, comparison between lure types was not practical. This sample size guaranteed an estimate of mortality for each treatment that is not more then 5% less than the true proportion 90% of the time. The 90% upper bound of which was calculated using:

$$90\% \text{ upper bound} = \hat{m}_i + \left(1.28 \times SE\left[\hat{m}_i\right]\right). \tag{3}$$

The length distributions for all gear types were compared using an Anderson-Darling k-sample test for sample homogeneity (Scholz and Stephens 1987). This analysis tested the null hypothesis that the cumulative length distributions were the similar.

The relationships between hook location and severity of bleeding were examined with chi-square tests on contingency tables (Zar 1984) of the data in order to test the null hypothesis that hook location is independent of bleeding severity. Also, the relationships between hook type with respect to hooking location and severity of bleeding and the effects of lure type, hooking location, severity of bleeding, playing time, and transport time on mortality were also examined.

For all tests, the following assumptions applied:

1. tagging, natural or handling mortality were minor and occurred equally among treatments;
2. there was no tag loss; and,
3. any mortalities which might occur after the 48 h confinement would not be a result of the study.

RESULTS

MORTALITY

A total of 63 sheefish were sampled with single hooks and 62 fish with the treble hooks. Thirteen controls were seined in order to establish the relationship of handling on mortality. An adequate sample size was achieved for both gear types. Yet, only 13 sheefish could be seined for the control group. Seining catch rates usually increase as spawning approaches because the fish are congregating near the spawning grounds. However, the water levels were high in 1997. High water creates a larger area to seine, thus reducing capture success. No mortalities resulted from seining (Table 2).

Mortality Rate

The mortality rate from the treble hook was twice as high (0.032, SE=0.022) as that for the single hook (0.016, SE=0.016, Table 2). To determine if the four sheefish that escaped from the pen had an effect on the mortality rates, analyses conducted with these fish included in the sample were compared to those with these fish removed from the sample. The inclusion and/or exclusion of these four data points had no significant effect on the mortality rates (Table 2).

Handling

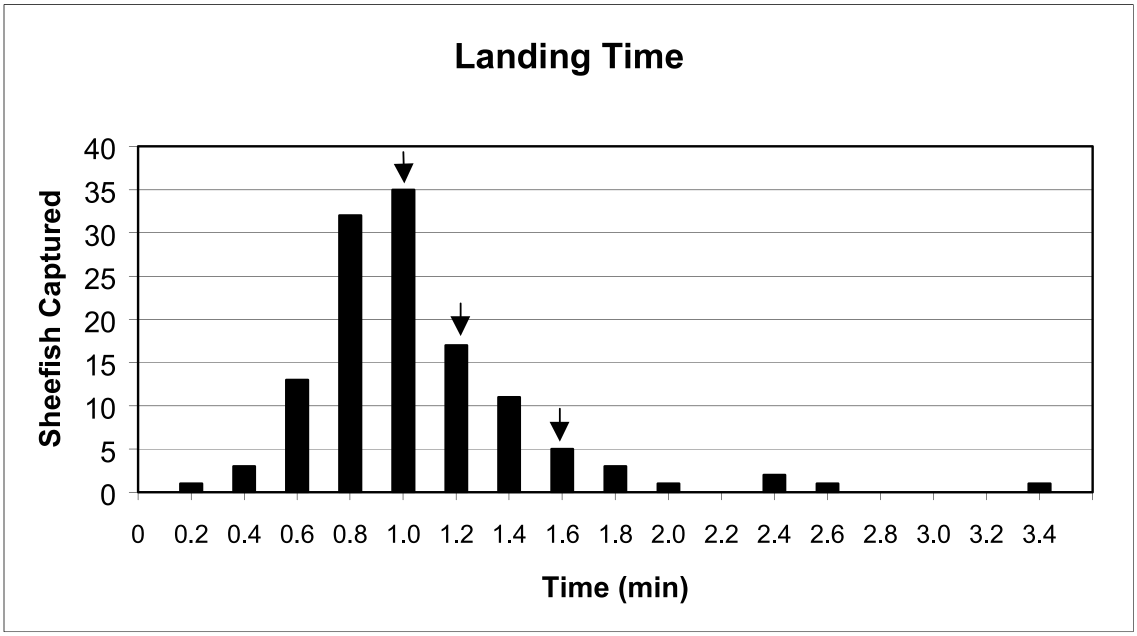
Due to the low mortality rate, no correlation could be made between landing times, handling times and fish mortality (Figure 3). Six fish were hooked in the gills. The three mortalities were hooked in the gills and experienced severe bleeding. These fish were discovered dead in the pen from 1 to 15 hours after release (Appendix A). The one fish that was hooked in the gills by a single hook bled severely and died. Two fish that were gilled by treble hooks showed no evidence of external bleeding. Three fish that were hooked in the gills by treble hooks showed severe bleeding and two died. Thus, there was an approximately 75% mortality for fish that were hooked in the gills and bleeding severely (SE=25%).

Of the three mortalities, two were male and one female. Males comprised 63% of the 134 fish of known sex, which were captured by sportfishing gear and seine. The female died as a result of capture by a single-hooked lure. The sheefish captured by single-hooked lure were an average of 864mm. The female that died was 1,018 mm and the largest of those captured by hook and line. The average length for fish captured by treble hook lures was 829 mm and 904 mm for the control group. The two male mortalities were 852 mm and 782 mm.

Table 2.-Mortality rates of sheefish captured and examined by two gear types on the Kobuk River, 1997.

Gear Type	Fish Captured	Mortalities	Escapees	Mortality Rate	SE	90% Upper Bound
Including Escaped Fish[a]						
Single Hook	63	1	2	0.016	0.016	0.036
Treble Hook	62	2	2	0.032	0.022	0.061
Both Gear Types	125	3	4	0.024	0.014	0.042
Control	13	0	0	0	0	0
Excluding Escaped Fish						
Single Hook	61	1	-	0.016	0.016	0.037
Treble Hook	60	2	-	0.033	0.023	0.063
Both Gear Types	121	3	-	0.025	0.014	0.043

[a] Refers to sheefish that escaped from holding during the 48 h waiting period.



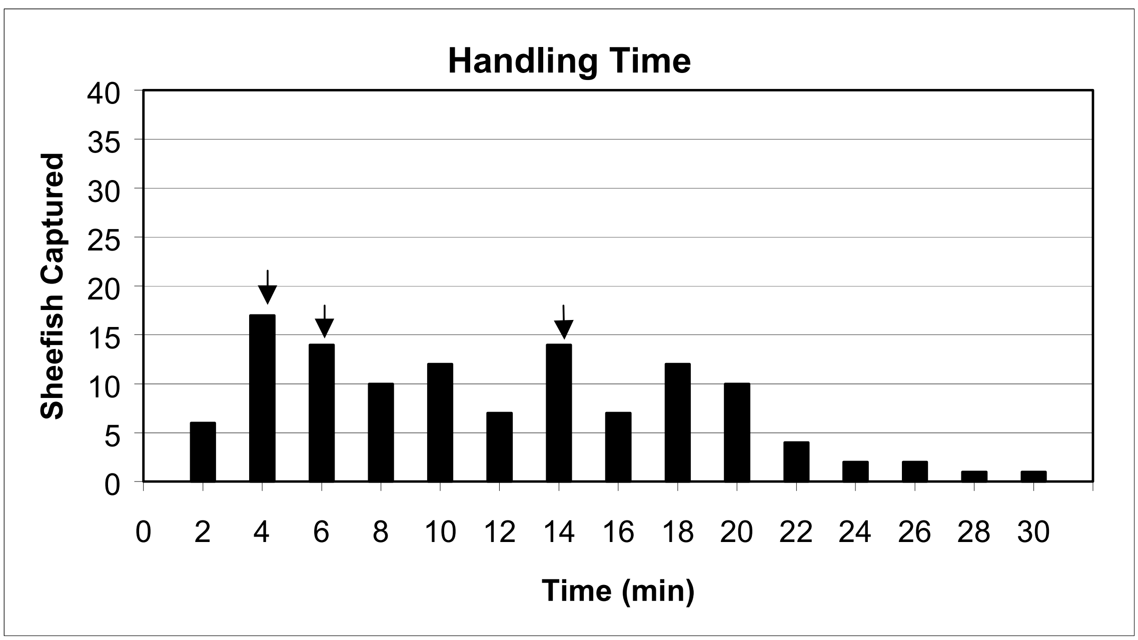


Figure 3.-Landing and handling times for sheefish captured by hook and line on the Kobuk River, 1997. Arrows indicate a fish that died as a result of capture.

LENGTH DISTRIBUTIONS

The Anderson-Darling k-sample test rejected the hypothesis of size homogeneity between the two gear types and the control (T_{kn}=64.02, $P \leq 0.01$). Single-hooked lures tended to catch larger fish than the treble hook lures (Figure 4). The median size captured by the single hook was 871 mm, the median size captured by the treble hooks was 825 mm, and the median for the control group was 893 mm.

HOOK-LOCATION/SEVERITY OF BLEEDING

Hook placement and bleeding data were put into general categories for analysis using contingency tables. Table 3 shows the relationships between gear type, hook location and severity of bleeding. No fish were hooked in the esophagus (3). A comparison between gear type and hook location failed to reject the null hypothesis that hook location is independent of hook type (χ^2=10.57, df=8 and P=0.23). Treble hooks had the ability to hook more than one location and tended to hook more often in the gills than the single hook. The most common hook locations for both gear types were the upper and lower jaws.

Similar results were shown for hook type and bleeding severity (Table 4). Bleeding severity was independent of hook type (χ^2=1.99, df=3, P=0.57). Only five of the 125 (4%) sheefish hooked by either lure type resulted in severe bleeding.

A comparison of hook location and bleeding for a combination of both gear types rejected the null hypothesis that hook placement is independent of bleeding (χ^2=90.86, df=24, $P \leq 0.01$, Table 5). Similar tests were also performed for each gear singly with similar results: for single hook, χ^2=58.41, df=15, $P \leq 0.01$, and for treble hook, χ^2=44.60, df=18, $P \leq 0.01$.

DISCUSSION

The hook and release mortality rates for both gear types were very small. Because there was only one death as a result of a single-hooked lure and two deaths attributed to treble hook lures, no tests were performed to examine mortality rates with respect to size, sex or fecundity. The sheefish that escaped from the pen were included in the analyses. Whether or not these four individuals were included did not significantly alter the mortality rates by more than 0.001. Table 2 shows the 90% upper bound to be small and to also not vary by the inclusion/exclusion of the four unaccounted sheefish. The pen was constructed so as to be secure from floating debris, river current and escaping sheefish. The fish would have had to be healthy to escape their predicament. Therefore, these fish were included in all further analyses on the strong assumption that they survived.

An Anderson-Darling k-sample test was performed on the fish lengths using the 125 hooked fish and 13 controls. The outcome showed significant differences in length frequency distributions between the two gear types and the control. Figure 3 shows median variations between three cumulative percent frequency distributions of the capture lengths. Visually, the single hook appears to have captured fish of a comparably larger size compared to the treble hook and the seine appears to have selected for larger size classes over both gear types.

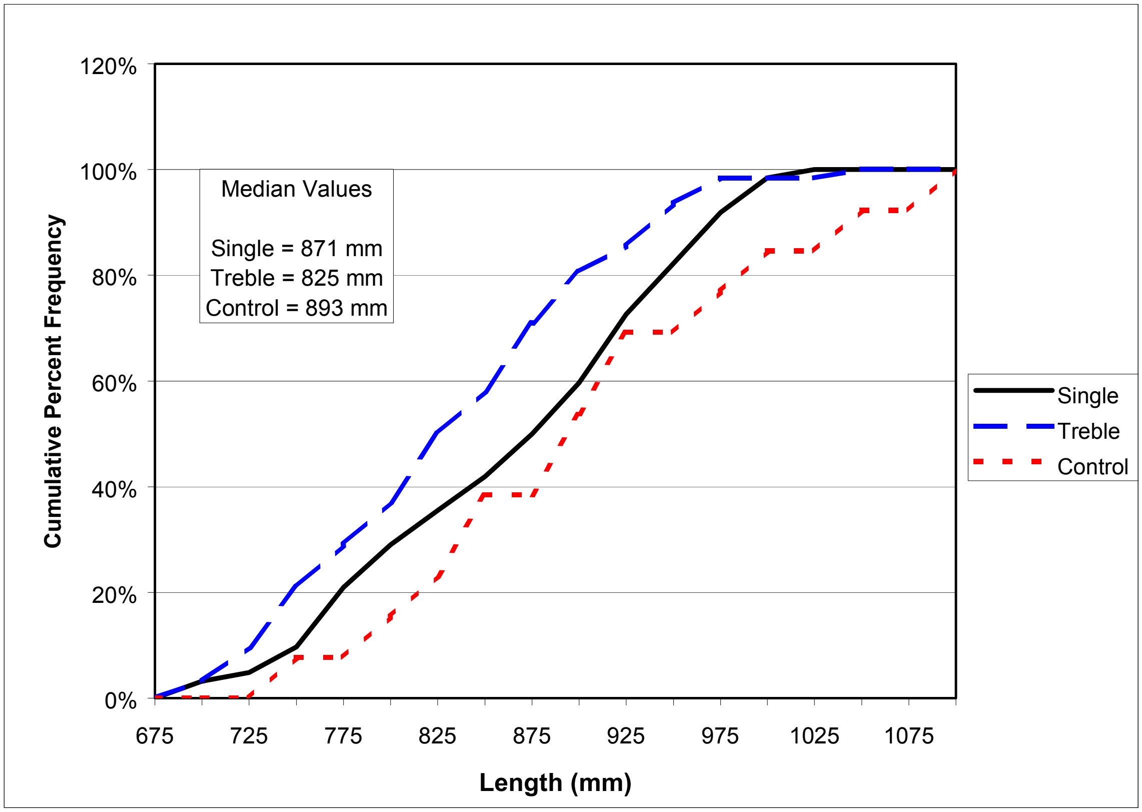


Figure 4.-Cumulative length frequency distributions comparing sheefish captured by single and treble hooked lures and seine during a hooking mortality study on the Kobuk River, 1997.

Table 3.-Relationship between lure types and hooking location for sheefish captured on the Kobuk River, 1997.

Gear Type	Hook Location[a]									
	1	2	3[b]	4	5	6	7	8	1&6	2&6
Single Hook	27	1	0	1	0	31	2	1	0	0
Treble Hook	22	0	0	5	1	29	1	0	3	1
Total	49	1	0	6	1	60	3	1	3	1
	χ^2=10.57, df=8, P=0.23									

[a] Treble hooks will hook a fish's mouth in more than one location.

[b] Since no fish were hooked in the esophagus, these values were not included in the chi-square analysis.

Table 4.-Relationship between lure types and bleeding severity for sheefish captured on the Kobuk River, 1997.

Gear Type	Bleeding Severity			
	0	1	2	3
Single Hook	26	24	11	2
Treble Hook	25	28	6	3
Total	51	52	17	5
	χ^2=1.99, df=3, P=0.57			

Table 5.-Relationship between hook location and severity of bleeding for sheefish captured with two lure types in the Kobuk River, 1997.

Single Hook	Hook Location[a]								
Bleeding	1	2	3[d]	4	5[d]	6	7	8	Total
0	16	1	0	0	0	8	1	0	26
1	6	0	0	0	0	17	0	1	24
2	5	0	0	0	0	6	0	0	11
3	0	0	0	1	0	0	1	0	2
Total	27	1	0	1	0	31	2	1	63
	χ^2=58.41, df=15, P$\leq$0.01								

Treble Hook	Hook Location[b]										
Bleeding	1	2[d]	3[d]	4	5	6	7	8[d]	1&6	2&6	Total
0	12	0	0	2	0	9	0	0	2	0	25
1	8	0	0	0	1	16	1	0	1	1	28
2	2	0	0	0	0	4	0	0	0	0	6
3	0	0	0	3	0	0	0	0	0	0	3
Total	22	0	0	5	1	29	1	0	3	1	62
	χ^2=44.60, df=18, P$\leq$0.01										

Total Hook	Hook Location										
Bleeding	1	2	3[d]	4	5	6	7	8	1&6[c]	2&6[c]	Total
0	28	1	0	2	0	17	1	0	2	0	51
1	14	0	0	0	1	33	1	1	1	1	52
2	7	0	0	0	0	10	0	0	0	0	17
3	0	0	0	4	0	0	1	0	0	0	5
Total	49	1	0	6	1	60	3	1	3	1	125
	χ^2=90.86, df=24, P$\leq$0.01										

[a] Single hooks did not hook sheefish in the tongue. Therefore, hook location 5 was excluded in order to perform chi-square test.

[b] Treble hooks did not hook sheefish in the eye or solely in the tongue. Therefore, hook locations 2 and 8 were excluded in order to perform chi-square test.

[c] Hook locations 1 and 6 and 2 and 6 pertain only to the treble hooked lures.

[d] These values were not included in the chi-square analyses.

Results of the contingency table analyses showed a correlation between hook placement and bleeding but no direct correlation between lure type, hook placement, and bleeding severity. This project was the first documented hooking mortality study performed on sheefish. Similar experiments were performed in the past on other large, northern, freshwater fish species. The rainbow trout hooking mortality study by Klein (1965) conducted a series of experiments designed to compare the effect of single and treble hooks. This rainbow trout study found that a single hook was taken farther into the mouth and inflicted a more serious wound while treble hook placement normally occurred near the edge of the mouth. For the sheefish hooking mortality experiment, neither hook type was swallowed. However, for this study relative hook size may have precluded injuries from swallowing. The treble hook lures tended to snag gills and hook more than one location in the fish's mouth. Wydoski (1977) showed an increase in mortality rate to salmon damaged in vital organs such as the gills. However, for the sheefish study, only 4% of the fish sampled were caught in the gills.

The sheefish hooking mortality study sampled fish in spawning condition. Approximately 20% of the spawners (96% male) were ripe. Although the effect of capture and subsequent handling and holding in a pen were proven negligible for the fish, the effect on spawning ability was not examined. Because sheefish are sought after by sport anglers who will release the majority of catches, the effect of hook and handling stress on sheefish would be valuable management information. Also, it would be good to understand the degree of effect on ripe vs. spawning (but not yet ripe) and males vs. females.

Burkholder et al. 1992, Falk et al. (1974), Hunsaker et al. (1970) and Carmichael et al. (1984) noted for their respective species that water temperature played a critical role in survival of fish which had undergone hooking and handling stresses. For any future sheefish studies, water temperature for the capture location, holding tub inside the boat, and holding pen should be closely observed and compared with baseline norms. Although handling time was shown not to be a critical factor in this study, it might have become critical if environmental factors were already stressing the fish.

The single and treble hooks used had intact barbs. The barbs were left on the hooks because it would be difficult to enforce the use of barbless hooks in this remote region of study. It was shown by Falk et al. (1974) on lake trout that removal of barbed hooks caused more damage than barbless hooks, and as a result, bleeding tended to be greater. However, Falk and Gillman (1975) showed in one study on Arctic grayling and northern pike that barbless hooks caused more damage than barbed hooks. This damage was primarily due to hook placement. Hook and line sampling conducted during mark-recapture experiments in the study area from 1994-1997 used hooks with barbs crimped down. Personal observations from the sampling crew concurred with Falk et al. (1974), that removal of barbed hooks caused more damage than barbless hooks. However, the crew had a higher success rate of capture with barbed hooks than barbless. Schill and Scarpella (1997) viewed barbed hook restrictions as more of a social issue. They concluded that based on existing biological data, barbed hook restrictions are not justified for resident salmonid fisheries.

Barbless hooks were not included in this study for the above reason and also over a concern whether a large enough sample of sheefish could be caught and held with additional treatments. Because mortality was low, it appears that holding approximately 60 sheefish for at least 48 h in a pen of the size used (approximately 50 ft square) is possible. Future hooking or handling mortality studies on sheefish could double sample size or number of treatments. The difficulty in increasing sample size may be collecting 120 sheefish in one sampling day. During the study, two crews of three people were used to collect sheefish by hook and line and seine in a 9 h sampling period. To increase sample size, greater effort would need to be used. Other influencing factors on catch rates are water conditions and spawning period. During sampling from 1994-1997, catch rates by hook and line of sheefish decreased as spawning approached (Taube 1997). In 1997, river levels were high and this may have reduced catch rates during the study. Past hook and line sampling in late August/early September 1995-1996 resulted in catches of over 100 sheefish in a 8 to 9 h sampling period for a crew of four to six people. Seining on the other hand improves as the spawning period approaches and the sheefish congregate off gravel bars.

Sheefish were captured on heavy tackle and gear, which may not be representative of the gear an average sport angler uses. Lighter tackle and gear would increase the landing time and stress on the fish and may increase mortality. From a management perspective, increased education of sport anglers who practice catch and release of sheefish could result in mortality rates comparable to this study.

ACKNOWLEDGMENTS

A note of appreciation to the field crew who conducted the sampling: Richard Barnes, Jim Fish, Amber Kocsis, Tracy Lingnau, Corey Schwanke, Dave Stoller, Klaus Wuttig, Randy Zarnke (ADF&G), Kenny Barr, Liz Evenson, Samantha Smith , Lance Astles , and Leslie Ruiz (NPS). Thanks also to Fred DeCicco for his assistance in planning, Mike Wallendorf for his biometrical assistance, Matt Evenson for reviewing and editing this report, Dr. Margaret Merritt for assistance in the coordination of the project, and Sara Case for final report preparations. A special thanks to the residents of the communities along the Kobuk River who provided additional information on Kobuk River sheefish.

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APPENDIX A

Appendix A.-Data on sheefish captured on the Kobuk River during the hooking mortality study conducted in 1997.

Lure Type (S or T)[a]	Date	Landing Time (min)[b]	Sex[c]	Length (mm)	Hook Location. (1-8)[d]	Bleeding (0-3)[d]	Handling Time (min)[e]
S	24-Aug	0.35	M(3)	728	1	0	17
S	24-Aug	0.42	F	865	6	1	13
S	24-Aug	0.43	F	925	1	0	6
S	24-Aug	0.52	M	731	1	2	13
S	24-Aug	0.58	M	745	6	1	10
S	24-Aug	0.62	M	770	6	2	15
S	24-Aug	0.62	U	837	1	2	4
S	24-Aug	0.62	M		1	2	14
S	24-Aug	0.67	F	843	6	0	17
S	24-Aug	0.75	F	905	6	1	5
S	24-Aug	0.83	M	804	6	0	13
S	24-Aug	0.85	F	922	6	0	25
S	24-Aug	0.9	M	767	6	1	17
S	24-Aug	0.93	U	848	1	0	17
S	24-Aug	1	F	930	1	0	21
S	24-Aug	1.17	F	930	7	0	6
S	24-Aug	1.2	F	898	1	0	13
S	24-Aug	1.27	M	855	1	1	21
S	24-Aug	1.33	M	765	6	1	5
S	24-Aug	2.33	M	765	6	1	10
S	11-Sep	0.5	M(3)	778	8	1	15
S	11-Sep	0.57	M	855	6	1	1
S	11-Sep	0.72	M	856	6	1	9
S	11-Sep	0.72	M	792	6	1	6
S	11-Sep	0.75	F	954	6	2	5
S	11-Sep	0.78	M	822	6	2	14
S	11-Sep	0.78	M(3)	770	6	1	4
S	11-Sep	0.78	F	929	6	0	4
S	11-Sep	0.78	M	771	1	0	9
S	11-Sep	0.78	M	690	6	1	9
S	11-Sep	0.85	F(3)	909	1	2	3
S	11-Sep	0.93	M	892	6	1	
S	11-Sep	0.97	M(3)	760	1	0	7
S	11-Sep	0.97	M	877	2	0	20
S[f]	11-Sep	0.97	M	822	1	0	17
S	11-Sep	1.05	F	973	1	2	15
S[f]	11-Sep	1.08	M	815	1	1	23
S	11-Sep	1.17	M	854	6	2	20
S	11-Sep	1.17	F	920	6	1	4
S	11-Sep	1.33	F	969	1	0	1

-continued-

Appendix A.-Page 2 of 4.

Lure Type (S or T)[a]	Date	Landing Time (min)[b]	Sex[c]	Length (mm)	Hook Location. (1-8)[d]	Bleeding (0-3)[d]	Handling Time (min)[e]
S	11-Sep	1.53	M	943	1	0	
S	11-Sep	1.62	F	912	6	0	8
S	11-Sep	1.68	M	699	7	3	4
S	11-Sep	2	F	918	6	0	4
S	11-Sep	2.25	F	940	6	1	2
S	14-Sep	0.2	M(3)	720	6	1	29
S	14-Sep	0.58	F	930	1	1	12
S	14-Sep	0.65	M(3)	783	1	1	14
S	14-Sep	0.68	M(3)	798	6	0	8
S	14-Sep	0.78	M	783	6	1	9
S	14-Sep	0.78	F	963	1	1	
S	14-Sep	0.78	M(3)	980	1	0	2
S	14-Sep	0.85	M	890	1	1	5
S	14-Sep	0.85	F	973	6	2	
S	14-Sep	0.97	M	885	1	0	8
S	14-Sep	1	F	990	6	1	20
S	14-Sep	1.08	F	889	6	2	14
S	14-Sep	1.08	M(3)	843	6	0	17
S	14-Sep	1.18	F	920	1	0	4
S	14-Sep	1.25	M(3)	994	1	0	27
S	14-Sep	1.28	F	952	1	0	4
S	14-Sep	1.33	F	989	1	0	13
S[g]	14-Sep	1.58	F	1018	4	3	5(1 hr)[h]
T	24-Aug	0.52	M(3)	718	6	1	4
T	24-Aug	0.55	M	751	6	1	16
T	24-Aug	0.58	F	907	1	0	5
T	24-Aug	0.62	M	733	6	1	12
T	24-Aug	0.7	M	849	1	1	14
T	24-Aug	0.75	M	720	1	0	7
T	24-Aug	0.75	M(3)	800	6	0	20
T	24-Aug	0.75	M	804	1	2	11
T	24-Aug	0.93	M(3)	698	6	1	19
T	24-Aug	0.97	U	803	1	0	3
T	24-Aug	0.98	F	931	6	1	15
T	24-Aug	1	M	745	4	3	22
T	24-Aug	1	M	811	6	1	9
T[g]	24-Aug	1	M	852	4	3	13(1hr 45min)[h]
T	24-Aug	1.08	F	895	1	0	10
T	24-Aug	1.1	U	783	6	2	5
T	24-Aug	1.3	M	749	1	0	4
T[g]	24-Aug	1.32	M	782	4	3	4(15hr 45min)[h]

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Appendix A.-Page 3 of 4.

Lure Type (S or T)[a]	Date	Landing Time (min)[b]	Sex[c]	Length (mm)	Hook Location. (1-8)[d]	Bleeding (0-3)[d]	Handling Time (min)[e]
T	24-Aug	1.47	M	843	1	0	11
T	24-Aug	1.5	F	970	6	0	6
T	11-Sep	0.38	M	820	1	1	6
T	11-Sep	0.5	M	715	6	1	20
T	11-Sep	0.63	F	830	1	2	16
T[f]	11-Sep	0.7	M	755	6	0	20
T	11-Sep	0.72	F	960	6	0	8
T	11-Sep	0.75	M	861	6	1	26
T	11-Sep	0.8	M(3)	809	6	0	6
T	11-Sep	0.83	M	784	6	0	13
T	11-Sep	0.83	M	727	6	0	14
T	11-Sep	0.83	M	844	6	1	18
T	11-Sep	0.85	F	960	6	1	16
T	11-Sep	0.87	M(3)	707	1	0	10
T	11-Sep	0.87	M	905	1	1	8
T	11-Sep	0.93	F	872	1	0	12
T	11-Sep	1	M	820	1	1	19
T	11-Sep	1	M	865	1&6	1	8
T	11-Sep	1	M	755	7	1	
T	11-Sep	1	M	890	1&6	0	
T	11-Sep	1.03	M	736	2&6	1	18
T	11-Sep	1.1	F	911	1	1	3
T	11-Sep	1.2	M	890	6	1	6
T	11-Sep	1.23	M	822	6	1	14
T	11-Sep	1.25	M(3)	755	6	2	17
T	11-Sep	1.63	M	864	1	0	10
T	11-Sep	2.5	M(3)	867	6&1	0	2
T	14-Sep	0.33	M(3)	827	6	2	4
T	14-Sep	0.42	M(3)	688	1	0	18
T	14-Sep	0.48	M	727	1	1	12
T	14-Sep	0.63	F	869	6	1	2
T[f]	14-Sep	0.67	M(3)	785	6	1	18
T	14-Sep	0.77	F	930	6	1	22
T	14-Sep	0.77	F	945	4	0	17
T	14-Sep	0.83	M(3)	887	1	0	20
T	14-Sep	0.95	M	883	4	0	10
T	14-Sep	0.97	M(3)	760	5	1	20
T	14-Sep	1	F	935	1	1	4
T	14-Sep	1.12	F	1035	1	0	10
T	14-Sep	1.17	M(3)	815	6	0	11
T	14-Sep	1.2	M(3)	865	1	1	8

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Appendix A.-Page 4 of 4.

Lure Type (S or T)[a]	Date	Landing (min)[b]	Sex[c]	Length (mm)	Hook Location. (1-8)[d]	Bleeding (0-3)[d]	Handling Time (min)[e]
T	14-Sep	1.23	F	926	6	1	4
T	14-Sep	1.42	M	749	6	2	24
T	14-Sep	3.25	F	892	6	0	8

[a] S denotes single hook lure and T denotes treble hook lure.

[b] Landing time is the time elapsed between when the sheefish is hooked to when it is landed on the boat.

[c] M(3) and F(3) is a ripe male or female. Gender unknown is labeled with U. Otherwise fish are in pre-spawning condition.

[d] Hook location and bleeding severity are defined in Table 1.

[e] Handling time is the time elapsed between landing and release into the holding pen.

[f] Denotes a sheefish that escaped holding pen and could not be accounted for at the end of the 48 h holding period.

[g] Denotes a sheefish that died as a result of the experiment.

[h] Amount of time elapsed after sheefish was placed in holding pen to when death was recorded.